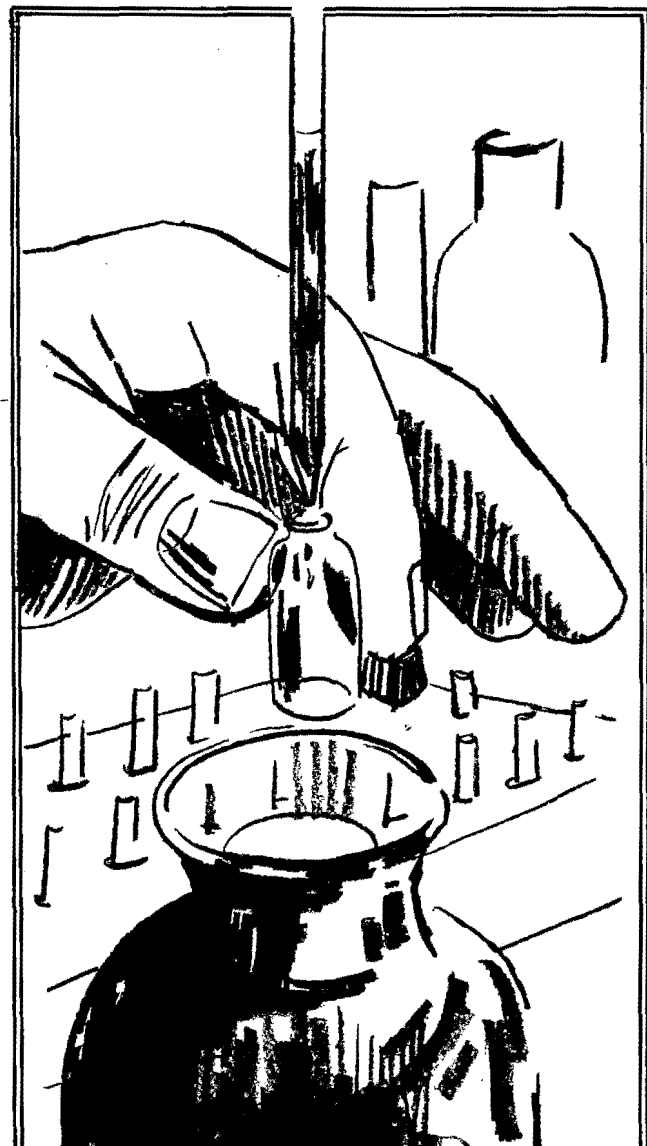
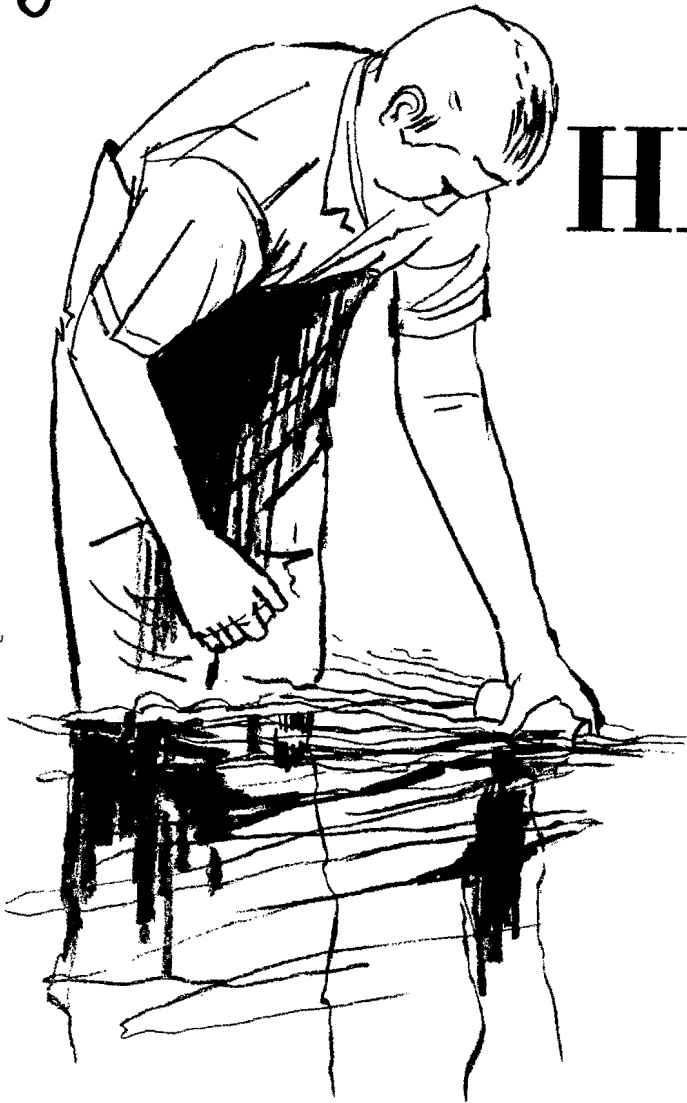


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WATER MONITORING FOR HERBICIDES



A FIELD GUIDE

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**A FIELD GUIDE
TO
WATER MONITORING FOR HERBICIDES**

MAY 1972

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**With Appendix by Jay R. Law,
Chairman, Chemical Use Committee**

PREFACE

In the last few years, there have been increasing demands for the watershed specialist to conduct water quality surveillance on the Forests of the Region. The monitoring of herbicide impacts is but one example of the type of surveillance which is needed. Of course, the brief report assembled here barely skims the immense topic of water quality; however, the information and suggestions provided hopefully will be of practical field use as a starting point for the watershed scientist. Good sampling!!

ACKNOWLEDGEMENTS

Robert Doerner and Murvin Johnson of our office were most helpful in preparing this report. For certain information supplied, appreciation is extended to the Northwest Pest Action Council, Forest Chemical Monitoring Subcommittee, P. G. Lauterbach, Chairman, and his associates, particularly in Forest Service Research. We also received monitoring information from John Hughes, Siuslaw National Forest. The cover is by Beverly Ebberts.

To: Users of Water Monitoring for Herbicides; Field Guide

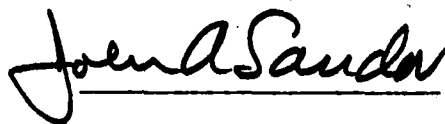
From: Regional Chemical Use Committee

In line with the Region's Interim Guidelines, the Chemical Use Committee has supported the practice of monitoring where the potential for introducing a herbicide into the water resource exists, or the method and/or chemical being applied is controversial. It should be the objectives of the monitoring to determine the amount of herbicide reaching the water, to assess the impacts of concentration detected against known tolerance limits for nontarget organisms, and to evaluate the need for continuing or improving upon the monitoring practice.

Through the efforts of the Region's water quality specialist, a committee member, the techniques of water sampling and information pertinent to monitoring for herbicides are now described in this Field Guide as an aid to the Forests. Proposals for herbicide monitoring need the authorization of the Forest Supervisor and should be submitted through the R-9 Chemical Use Committee prior to initiation for review. Those projects selected must bear the cost of monitoring.

A summary of current policy and practices along with the R-9 Interim Guidelines for using herbicides is attached. Monitoring should not serve as an end in itself but as one of the tools which may be used by the land manager to assess the effectiveness of the guidelines and to measure the impact of his action in quantitative terms.

Approved by:



JOHN A. SANDOR
Deputy Regional Forester

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PART I: WHY MONITOR FOR WATER QUALITY?

This section considers the usefulness of water quality monitoring and provides some general guidelines on planning a monitoring project.

More and more, Forest Service hydrologists and engineers are called on to monitor and evaluate the water quality of streams, lakes, reservoirs, and ground water on the public lands we manage. We may need to identify pollution sources, evaluate a particular land use impact, establish baseline information against which to evaluate later management impacts, or make predictions of probable future water quality. Water quality data, when correctly collected and interpreted into useful form, can be a very valuable tool for many land management programs.

1. Land Use Planning: The identification of preferable recreation sites in reservoirs, of clean water supplies, and of other factors are sometimes vital inputs for planning land use. Likewise, specific pollution hazards need to be pinpointed for the land manager. In some cases, water data will be needed to predict probable future water quality; for example, for a proposed reservoir site.

2. Impact Analysis: The public often asks for evidence that certain land management activities, for example timber harvesting, do not pollute waters. Forest Service professionals likewise agree that these questions should be answered with the needed quantitative answers. Adequate but feasible impact surveillance programs therefore are essential. Other impacts in question include herbicide use, recreation, road building, grazing, wildlife, and impoundments.

3. Legal Evidence: In certain instances of strip mining trespass or similar problems, the Forest Service may need court evidence of water pollution. A specially designed, short-range water monitoring program is of key importance in such cases.

4. Recreation: To insure human health protection, recreation waters often must be monitored for pathogens. Also, ski developments, lakeshore dwellings, and other recreation features may cause contamination problems. A water surveillance program can call attention to problem sites.

5. Waste Disposal: New methods of disposal and increased demands for waste disposal on Forest lands raise questions about potential water pollution. Monitoring at spray irrigation sites cannot only help assure health safety, but aid in developing methodology in the disposal systems (for example, by monitoring the leachate, the extent of nutrient uptake in a particular soil can be observed).

6. Eutrophication: In some areas, the utility of lakes is endangered by excessive fertilization, from sewage or other sources. We need to pinpoint problem lake sites and recommend solutions; for this, water quality surveillance is needed. In the Lake States, the challenge is to identify key problem areas by using the fewest possible parameters and samples. (There is neither time nor money for the "shotgun approach" to monitoring thousands of lakes.)

7. Productivity: In lakes and streams where recreational fishing is important, we need more details on how to strike the balance between optimum productivity of waters and an acceptable quality of recreation waters. Water quality monitoring ties closely to aquatic habitat evaluation in such cases; therefore, monitoring also can be of importance from a fish management viewpoint.

8. Land Purchase: In areas of proposed reservoirs, planned recreation sites, and other planned uses, water quality data could be a valuable aid in selecting top priority tracts to purchase. For example, there may be areas where purchase could eliminate an activity which is particularly detrimental to water quality at a recreation site (for example, a tract of houses with raw sewer outfalls). In lake areas, development of water quality indices of lake "carrying capacity" is under investigation at this time. Such indices could be invaluable in identifying preferred lakes for shoreline purchase and development.

9. Restoration Effects: Restoration projects may in some cases need evaluation in reference to water quality improvement.

10. Political or Public Relations Needs: In certain situations the Forest Service indirectly becomes involved in water quality issues; for example, in reference to dam construction by another agency. In such cases, water monitoring information can be a valuable reference to aid in arriving at Forest Service opinion on the particular project.

As detailed briefly above, there are many needs for monitoring. We need to avoid either unplanned monitoring or the all-inclusive approach to sampling. In general, we recommend the "Four-pronged Attack," which may be useful:

1. Problem Identification: Usually there is an abundance of water quality monitoring needs, but sometimes the Forest Supervisors and hydrologists may have a problem emphasizing top priority projects to monitor. Inviting "outsiders" in for tours on the Forest and hearing their impressions may be useful. Likewise, closer contact between hydrologist and District Ranger may in some instances be helpful. Regional Office personnel also can be requested for functional assistance.

2. Planning: Plan each monitoring program in detail and generally select the fewest parameters possible. Sometimes it may be necessary to measure many parameters early in the program, then use these "pilot study" results to concentrate on a few factors. More samples of a few parameters are often preferable to few samples of many parameters, once key parameters are found. Write a study plan and have it reviewed by others. Spell out objectives, schedules, logistics, data reduction plans and the termination date in detail. In stream projects, look for opportunities to tie the water quality sampling to stream discharge measurements; these two aspects are in many ways inseparable once the time for data interpretation arrives. If necessary, set up temporary stream discharge sites, even if only of a crude nature. Sometimes, "control points" or natural stream measurements will be needed for reference, especially in impact monitoring or legal cases. Do not set out to collect data without good planning. The seemingly "busy work" of a written work plan often can save many hours in the long haul. Failure to prepare such a plan has resulted in collection of excessive data in some cases on the Forests.

3. Data Collecting: Field collection of data should be adequate, yet it is important not to continue to collect data once the stated objectives have in fact been met and the specific questions answered. It is very advantageous to keep data up to date by plotting simple charts and graphs as the study progresses. Don't accumulate raw data, waiting for completion of the project. If data are to be reduced for possible computer analysis, "IBM" forms or other formats which the keypuncher will accept are preferable.

4. Data Analysis and Follow-Through: Look for ways to present the data in useful formats, for example, with graphs, charts, or simple statistics. Generally, avoid presenting raw data (unless as an appendix). For the most part, technical jargon should be avoided, and the results should be written up as much as possible in language of meaning to non-hydrologists on the Forest staff. Interpretations are particularly essential if the report is to be useful on the ground. In many cases specific recommendations also definitely should be included. Ideally, the water scientist should work on a draft report early in the project, while field observations are still fresh in mind. Then have the draft reviewed by non-hydrologists to see if you are communicating. Include an abstract or summary, which should preface the report. In summary, above all the report should be useful. The specialist especially must communicate to the decision-maker in clear fashion, and the implications of technical data need to be spelled out. This communication is the responsibility of the specialist.

PART II: MONITORING TECHNIQUES

This section considers sampling techniques, especially as related to hydrology, and discusses some of the available equipment.

1. Sampling and Variations: Stream sampling is an art, demanding knowledge of hydrology, physical geography, and land use impacts. We know, for example, that during storms many streams carry drastically higher concentrations of suspended sediment than during quiet flows, as illustrated by the actual data of Figure 1. On the other hand, streams may show decreased concentrations of dissolved chemicals during high flows, as shown in the Figure 2 data taken from one of the same streams. Of course, the type of water quality impact to be monitored is vitally important when planning sampling. For example, bacteria concentrations in streams are very much a function of the several interrelated factors. Storm runoff on pasture land can flush bacteria into a stream, thereby raising stream concentrations. Conversely, storm runoff will cause dilution in a stream receiving sewage, hence lowering bacteria concentrations. 1/ Such interacting factors must be considered when selecting sampling sites and preparing monitoring plans. Likewise, snowmelt runoff may dilute the effluent from a farmhouse sewer pipe, lowering nitrate concentrations while at the same time the melting snow may wash manure into the stream, raising nitrate concentrations. The net result is a mixture of the two effects.

2. Storm Sampling: In stream monitoring work, storms are "where the action is." They provide a graphic illustration of the fluctuations of water quality parameters. The hydrologist may want to sample storm runoff to observe extremes (either high or low), to watch for flushing effects or to calculate the volume of a material being transported (for example, sediment). The most pertinent data often are from storms. In the case of herbicide monitoring, for example, we especially want to catch a sample of runoff during the first storm following spraying.

A grab sample may be taken in whatever container works best, usually a polyethylene bottle. 2/ A more representative sample can be taken with a so-called "depth-integrating hand sampler" (Table 1). In

1/ Kunkle, S. H. 1972. Sources and transport of bacterial indicators in rural streams. American Society of Civil Engineers, Proceedings.

2/ In collecting certain herbicides or other chemicals, glass bottles are necessary.

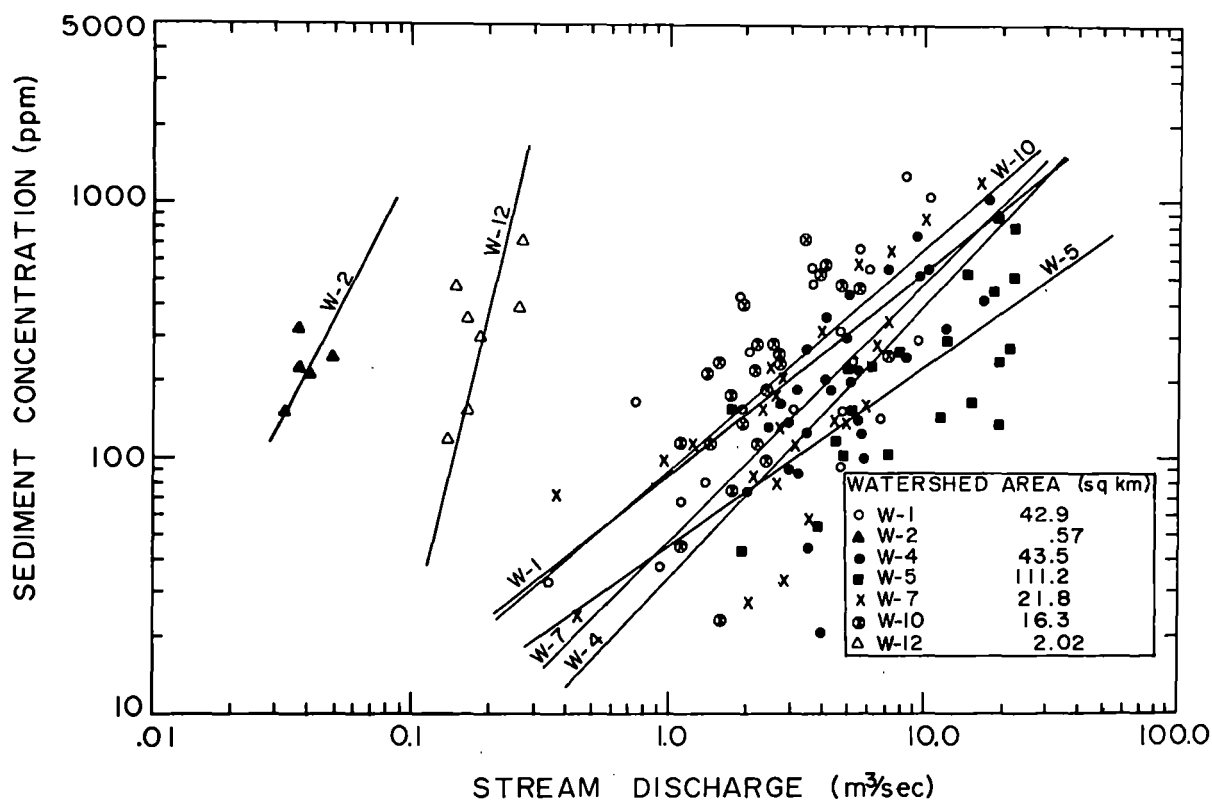


Figure 1. Suspended sediment in several northern Vermont streams as related to stream discharge (data from Kunkle and Comer, 1971, Suspended, bed, and dissolved loads in the Sleepers River. USDA. Agricultural Research Service Bulletin.)

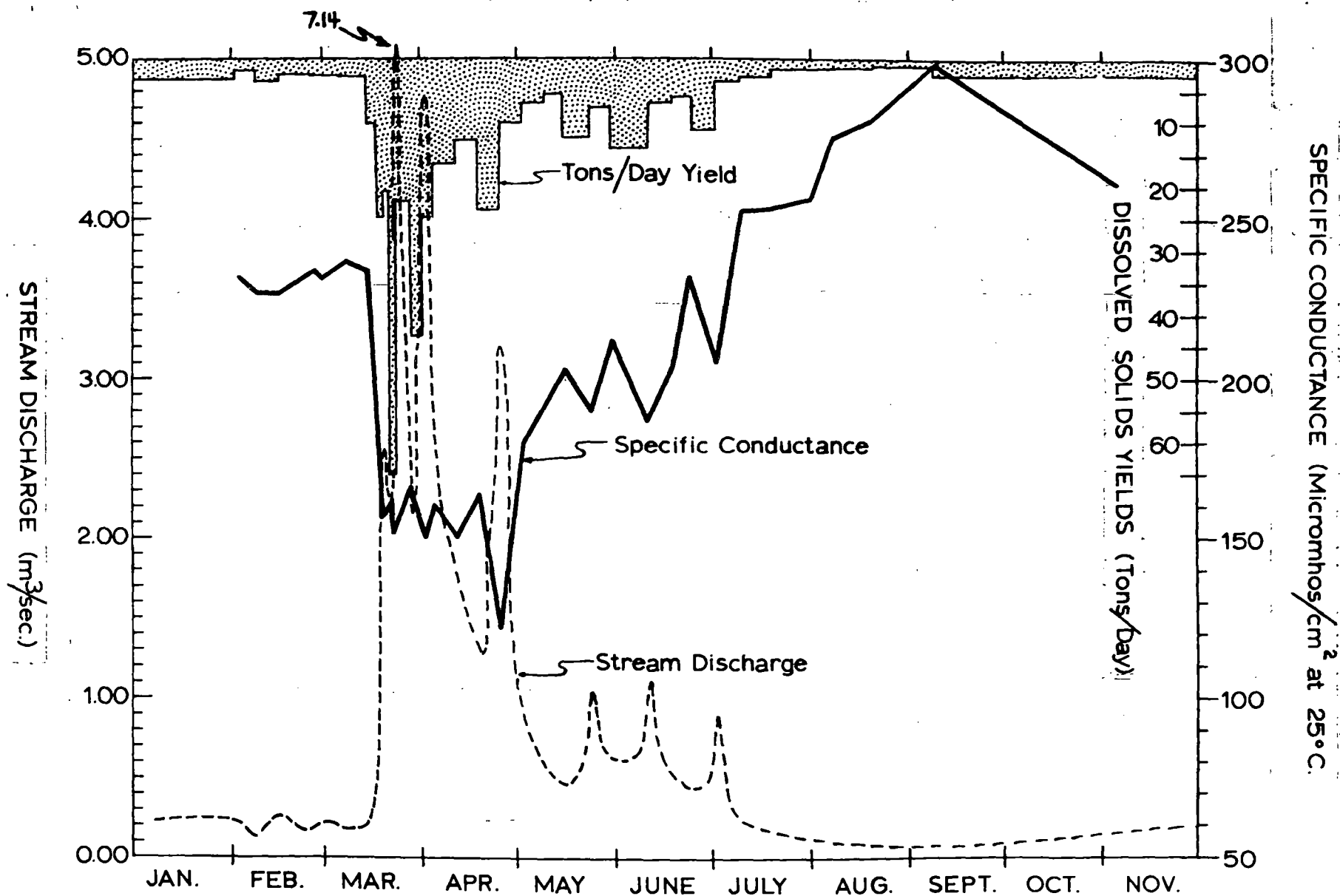


Figure 2. Relationship between dissolved solids and stream discharge in a headwater, forested watershed of Vermont.

this case, as the sampler is moved up and down, an integrated sample is collected from the vertical cross-section of the stream. Integrated sampling is especially important in reference to suspended sediment monitoring, but usually of little importance in reference to chemicals in solution in small, mixed streams of the type we often monitor.

There is no substitute for a sample gathered personally during a storm. Sometimes an important piece of storm water quality data can be explained by an on-site field observation made during the storm (e.g., a beaver pond had just given way upstream, etc.).

3. Automatic Samplers: The field hydrologist soon finds that storms occur at 2:00 a.m. Also, he notes that the metal handle of the depth integrating hand sampler serves well as a lightning rod, especially when one is standing in a stream. Therefore, automatic samplers have become useful and popular, whereby storms can be sampled remotely, with bottles collected a few hours later. Preservatives may be added to the bottles prior to filling, if desired.

The simplest automatic samplers work on a siphoning principle. As stormflow rises, the water siphons into a bottle. Many variations on this theme have been developed by commercial firms as well, as described in Table 1.

Some sanitary engineers and hydrologists are concerned with the vertical distribution of transported matter in streams, particularly suspended material, which tends to stratify. Some automatic samplers overcome this variation by moving a scoop up and down, gathering an integrated sample (similar to the "depth-integrating" hand sampler). Such an arrangement is subject to mechanical problems and is not always needed.

Several Federal research stations have invested much money and time trying to develop the "perfect water sampler." One research station, for example, worked for several years to perfect a very sophisticated sampler for use in monitoring pesticides in storm runoff. Last year they concluded that essentially the sampler was too elaborate for field use. (Among other problems, lightning commonly knocked out the electronics during storms, of course.) Other agencies continue work on the "perfect sampler." In general these sophisticated instruments are not useful in general field use, but only in research situations where they can be nursed along. The Army Corps of Engineers, the Agricultural Research Service, and other agencies are continuing development of smaller versions of samplers, and although most models appear too involved for general field purposes, better field versions may yet appear.

Sanitary engineers often use simple composite samplers at treatment plants, such as described in Table 1. These commercial samplers are sturdy, relatively cheap, and quite useful, if a composite sample is acceptable. Some brands also measure flow at the same time. Not all of these instruments are suitable for field use, but would be useful in monitoring at a waste treatment site.

Several commercial samplers are available which lack the ability to integrate a stream's vertical cross-section, yet have the important advantage of being suitable for field use and simple to operate. Several such samplers are described in Table 1, such as sampler number 5. These portable samplers are especially useful in most watershed studies. For example, some samplers have several vacuum pump evacuated bottles which suck up samples as a clock arm moves past and snaps open a series of pinch valves (such as samplers numbered 8, 9, 10, 11, and 12, Table 1). A 24-bottle version also is sold by two companies. Some samplers have provisions for inserting a coolant can, to keep samples cool for a few hours (of value in bacteria sampling). Unfortunately, most of these simple samplers are relatively expensive. Construction of homemade versions also may be worth considering since funds are often tight.

Whether a hydrologist can design and build his own samplers is, of course, a matter of the individual; however, be advised that such development is invariably more time-consuming than expected (the grumbling of experience), and probably not justifiable.

Most of the commercial samplers usually are sold to treatment plant operators, who are not concerned with remote locations. Therefore, these samplers are not equipped to be triggered remotely. It may be desirable to develop a homemade triggering device, such as our example in Figure 3. Spokesmen for some companies also indicate that they will supply the necessary triggering switch to the electric clocks on their samplers, for a small additional cost.

The weight, size, and power requirements of samplers often are limiting factors in terms of field use. Desirable field features from our viewpoint generally include: portability, numerous bottles, adjustable sampling intervals, and no need for external power. Samplers 2, 8, 9, 10, and 12 particularly are possible selections for field use. There is no "perfect" or standard automatic sampler and the advantages and disadvantages of each brand must be weighed. All the companies have brochures available, and the Regional Hydrologist can advise on the models.

4. Lakes: Sampling of ponds and lakes typically is carried out with samplers designed for filling at desired depths. Several of these samplers are described briefly in Table 1. A special sampler is used in the case of dissolved oxygen, whereby an "undisturbed"

Notes and Comment

COMPACT TRIGGERING DEVICE FOR PORTABLE AUTOMATIC WATER SAMPLERS

Samuel H. Kunkle and Russell J. Houghton

An inexpensive triggering device has been developed for use on automatic water samplers at the Sleepers River Experimental Watershed in Danville, Vt. For use at remote watershed sites, the device activates a sampler when runoff raises the stream stage to a designated level. The instrument (Fig. 1) was designed for use on Serco Automatic Samplers.* With slight alterations, however, the device could trigger other samplers, could release cameras, or perform numerous tasks.

The device is easily constructed using 3-mm ($\frac{1}{8}$ in.) aluminum stock on which are mounted the lever, solenoid, battery, and other working parts (Fig. 1). Total weight, including battery, is 275 g (9.7 oz) and dimensions are $10 \times 10 \times 3.3$ cm ($4\frac{3}{8} \times 4\frac{3}{8} \times 1\frac{5}{16}$ in.). Cost of materials is approximately \$7.00. The entire instrument is mounted inside the automatic sampler by attaching it, by four wing nuts, to the existing screws on the clock. The clocks available with the Serco sampler may be readily interchanged.

Operation of the device is simple. When contact between the two wires is made at the water level recorder (Fig. 2), the solenoid (G) pulls a lever (A), thereby releasing the spring-

Submitted by Samuel H. Kunkle, Research Hydrologist, and Russell J. Houghton, Electrical Engr., both of the Northeast Branch, Soil and Water Conservation Research Div., Agricultural Research Svc., US Dept. of Agriculture, Danville, Vt. [X]

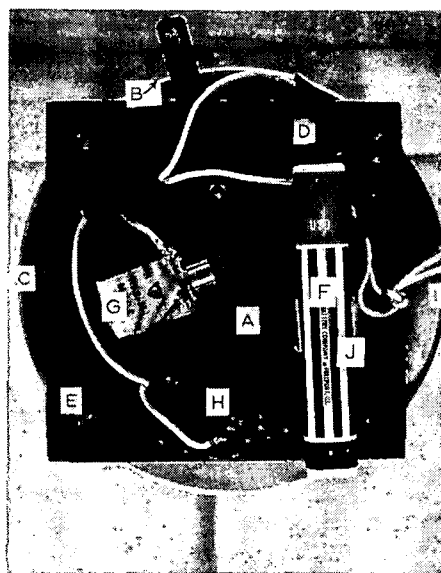


Fig. 1. Triggering Device

(A) Lever arm. (B) Spring-loaded sliding pin. (C) Clock. (D) Battery clip. (E) Aluminum stock. (F) Forty-five volt battery. (G) Twenty-four volt solenoid. (H) Microswitch. (I) Lead wires. (J) Battery mount.

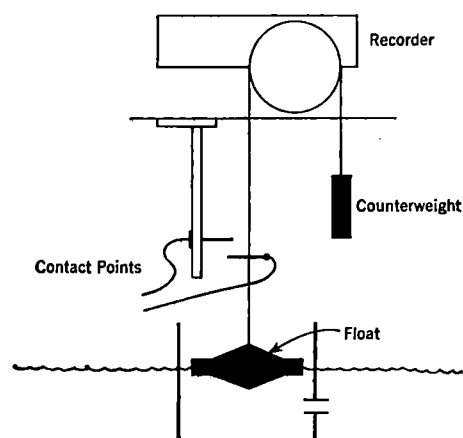


Fig. 2. Diagram of Contact Points and Method of Activating the Triggering Device

loaded sliding pin (B) from its compressed position against the clock's escapement, allowing the clock to start. To eliminate battery drain, a roller-type microswitch (H) breaks the circuit as soon as the clock is activated. The contact points are 3-mm ($\frac{1}{8}$ in.) pins. One is mounted on a brass rod and may be adjusted to the desired level; the other is attached to the steel tape of the recorder. Flexibility of the tape allows the two pins to pass after contact. The inlet to the stilling well must be small, to minimize surge and to avoid accidental activation of the sampler. Further details are available from the authors.

* Product of the Sanitary Engineering Research Co., Minneapolis. This mention does not necessarily imply endorsement by the USDA.

Figure 3. Example of a sampler triggering device found very useful.

lake sample can be taken in its natural state, without added aeration during sampling. Many variations and innovations are available in these samplers, and prices likewise cover a wide range.

Generally, lake water sampling may be based on a sampling grid within the lake or one may return to a marker buoy in some cases. Sampling at a lake outflow point may be easiest and quite suitable in situations where lake throughflow is consistent and where accessibility is not a problem. Recreation sampling at lakes will naturally be tied to patterns of human use. Sampling frequencies may be based on routine seasonal schedules, and often tied to lake turnover and aquatic biological activities, depending on sampling objectives. For further details, contact the Regional Hydrologist and Biologist. A handy reference (the Forests reportedly have) is: The Practice of Water Pollution Biology by Mackenthun (1969), which is a 281 page paperback released by the Department of Interior. This booklet also has about 400 pertinent references. Several of the basic limnology texts consider sampling, including Hutchinson, G. E., 1957, A Treatise on Limnology, John Wiley, 1015 pages (rather intensive, also expensive), and Ruttner, F. Fundamentals of Limnology, 1965, University of Toronto Press, 250 pages (about \$10). The biologist at the Regional Water Quality Laboratory particularly can assist in these questions of lake sampling.

5. Subsurface Water: Ground water and soil water sampling is important at some sites; for example, on areas where shallow water tables are subject to contamination. Where drinking water supplies are taken from wells or springs, periodic sampling usually is desirable to detect any pollution from septic systems, road salt, or other sources. We also may need to monitor contamination of subsurface water at waste disposal sites (spray irrigation areas, dumps, etc.). Several kinds of suction devices, porous cups, and lysimeters may be used to sample either ground water, perched water tables, or the "unsaturated" soil water. These various ground water sampling devices commonly are used by agricultural researchers. Table 1 describes some models.

6. Other Monitoring Devices: In recent years continuous monitors also have been developed for certain water quality parameters; for example, specific electrical conductivity and pH. More elaborate continuous monitors (for numerous parameters) also are available, but not in the price range of our interest. We should continue consideration of constant monitoring for selected, simple indices (e.g. conductance), especially in those cases where fluctuations are of interest; for example, for acid mine drainage monitoring.

7. Summary: As discussed briefly in this section, water sampling is much more than just filling bottles. To gather good water quality data one must consider storms and other hydrologic activities, the particular impact at hand, the season, and many other factors. Good sampling is a mixture of scientific hydrology, wet boots, statistical design, and gadgeteering.

TABLE 1 - LIST OF SOME OF THE AVAILABLE SAMPLERS

<u>Brand, Size, Weight</u>	<u>Description and Remarks</u>
(1) "U.S. DH-depth-integrating hand sampler." U.S. St. Anthony Falls Lab., 3rd Avenue SE & Mississippi. Minneapolis, 55414 - about 15 X 20 cm, plus handle; about 1 kg.	The "standard" hand sampler for use on small streams. Cost about \$75. Also, several heavier models are available for suspension from bridges over large streams. (Wading rod usually not supplied with the sampler.)
(2) Single stage sampler, "homemade." Designed by St. Anthony Lab. (address above) Milk bottle size. Portable.	These samplers, a bottle and tube arrangement, collect on the rising stage by siphoning. Cost nominal, involving bottles and some tubing. In Lake States the flat topography may not display adequate stream stage fluctuations for easy use of these samplers at some sites. There are several variations on the design.
(3) The "Freeman Sampler." Freeman Associates, 8807 Littlewood Road, Baltimore 34, Maryland (301) 665-1401. Each module about 15 X 15 X 30 cm; perhaps 500 g.	A modular construction model which uses "fluidic valving" to essentially siphon in a sample at various stream stages. PVC construction. About \$50 per module. Uses Mason jars. On market in 1971. Probably would be difficult to use in Lake States, possibly very suitable in some other areas.
(4) "Trebler Sampler." Lakeside Engineering Co., 222 West Adams Street, Chicago, Illinois 60606. About 1 X 1 m; perhaps 20 kg. Stationary.	For use in weir box or flume. Takes long-term representative samples from vertical cross-section and <u>composites</u> the samples. About \$850. Needs 110 v. power. Adjustable clock. Sample refrigerator available. Several moving parts. Needs housing.
(5) "Krofta Sampler." Krofta Engineering Corp., 58 Yokum Avenue, Lenox, Mass. (413) 637-0740 35 X 20 X 35 cm; perhaps 15 kg. Portable.	Field type. Battery powered. Samples every 15-30 minutes; composites the samples in a 12 liter bottle. Aliquot size adjustable. Lifts to 6 meters head. Construction appears simple. Cost \$385.

TABLE 1 (Continued)

Brand, Size, Weight

Description and Remarks

- | | |
|---|--|
| <p>(6) "Parshall Flume Sampler" (also measures discharge). Black-Clawson-Drofta Co., 605 Clark St., Middletown, Ohio 45042 (513) 422-4561. Stationary. About 100 X 20 X 20 cm; perhaps 20 kg.</p> | <p>Takes sample and measures average flow in a flume. Samples proportional to flow. Composites a large sample from aliquots every 7.5 minutes. Needs housing, 110 v. power. All samples taken at 8 mm. from flume bottom, hence some bias toward larger sediment particles. Cost about \$850.</p> |
| <p>(7) "U.S. PS-69 Sampler". St. Anthony Falls Lab., 3rd Ave. S.E. & Mississippi, Minneapolis 55414. 180 X 95 X 145 cm. 77 kg.</p> | <p>One of the several samplers designed by Federal agencies (we have one in use). Collects up to 72 samples. Large, rather complicated; this model not recommended. Cost \$1,450. Not portable. Smaller models also under testing during the last few years. Further information on these at USDA Sediment Lab., Oxford, Mississippi.</p> |
| <p>(8) "Automatic Shift Sampler." Paul Noascono Co., 805 Illinois Ave., Collinsville, Ill. 62234 (618) 334-3706. About 120 X 40 X 55 cm. Fairly portable, enclosed. Weight 39 kg. (unfilled).</p> | <p>Portable sampler in stainless steel box. Cost about \$350. Ten individual 1 gallon glass bottles. 110 v. peristaltic pump. Lifts about 8 m. head. Samples about 500 m./hr. 10 bottles in sampler. Individual bottles. Various timing arrangements available. Needs AC power source.</p> |
| <p>(9) "Automatic Liquid Sampler." Testing Machines, Inc., 400 Bayview Avenue, Amityville, L.I., N.Y. 11701 (516) 498-1400 - 37 X 66 cm.; 16 kg (unfilled). Very portable.</p> | <p>Twelve separate 570 ml. bottles (takes 450 ml. samples). Various clock arrangements available, to take samples at 1/2 hr., 1 hr., or every 2 hrs. Total cost about \$600. Hand-operated pump and spring clock - <u>no external power required</u>. Separate tube for each sample.</p> |
| <p>(10) "Serco Automatic Sampler." Serco Corp., 4205 31st Ave. S., Minneapolis, (612) 729-2067. 68 X 40 X 40 cm. 23 kg. (unfilled).</p> | <p>A self-contained sampler for field use where no external power available. Aluminum housing. 24 separate samples. About 200-400 ml. per sample, depending on lift. Sampler must be evacuated in laboratory using 110 v. vacuum pump. Cost about \$1,000. Fairly compact and simple. Portable. Various clocks available. From every 5 min. to 1 per hr. Sampling frequency. Somewhat sensitive to movement once evacuated, in our experience.</p> |

TABLE 1 (Continued)

Brand, Size, Weight

Description and Remarks

- | | |
|--|---|
| <p>(11) "Sigmamotor 115 v. Model WM-1-24R." Sigmamotor, Inc., 14 Elizabeth St., Middleport, N.Y. 14105. (716) 735-3616. 83 X 50 X 53 cm. 56 kg. (Company makes a variety of samplers.)</p> | <p>Samples from every 10 min. to 1 per hr. 450 ml. samples; 24 polyethylene bottles. Cost: over \$1,500. Refrigerated. Needs 110 v. Lifts to 7 meters head. Tubing automatically purged after each sample. 7½ m. of tubing. A similar nonrefrigerated 110 v. Model costs \$1,050. A composite 110 v. sampler Model costs \$450.</p> |
| <p>(12) "Sigmamotor 12v. Model WM-2-24" (address above). 35 X 32 X 60 cm. Weight: 16 kg.</p> | <p>Very similar to above sampler except battery powered and not refrigerated. Cost: about \$1,300. Battery charge <u>only runs one cycle</u>. Recharge time 16 hrs. Extra battery pack and charger \$264. Electrical switch for automatic triggering will be installed extra by company for \$20.</p> |
| <p>(13) Wildlife Supply Company, 220 South Hamilton St., Saginaw, Mich. 48602.</p> | <p>Company sells variety of limnologic equipment and reportedly gives good service.</p> |
| <p>(14) "Niskin Sampling Bottle." General Oceanics, Inc., 5535 NW 7th Ave., Miami, Florida 33127 (305) 754-6658. Various sizes.</p> | <p>Company sells several types of samplers suitable for limnologic sampling. In capacities from 1.7 to 30 liters, in single and multi-bottle arrangements. Messenger operated. From \$180 to \$375 each.</p> |
| <p>(15) Oceanography unlimited water samplers. Oceanography Unlimited, Inc., 108 Main St., Lode, N.J. 07644 (201) 779-2313.</p> | <p>Company sells several models of limnologic samplers, usually messenger operated. PVC, glass, and teflon models from \$20 to \$375 each. The simple glass, \$20 model, is suitable for lake sampling to about 15 meters.</p> |
| <p>(16) "Hydro Products" sampler. Hydro Products, P.O. Box 2528, San Diego, California 92112 (714) 453-2345.</p> | <p>Van Dorn and other types of limnologic samplers. Plexiglass or PVC construction. From 1 to 16 liter sizes. Messenger operated. 1 to 4 liter, \$75 to \$100 each.</p> |
| <p>(17) Kahl Scientific Instrument Corporation Samplers, P.O. Box 1166, El Cajon, California 92022 (714) 444-5944.</p> | <p>Company sells a variety of limnologic samplers of Van Dorn and Kemmerer type in plastic and glass. Also features a patented aseptic type glass sampler for bacteriologic studies at varied lake depths.</p> |

TABLE 1 (Continued)

Brand, Size, Weight

Description and Remarks

(18) Hach's Model 1962 DO Sampler. Hach Chemical Co., Box 907, Ames, Iowa 50010. (515) 232-2533. 2 kg; 18 X 8 cm.

A simple PVC sampler for lagoon or pond DO measurements (\$20). Has 3.3 meter brass chain. Designed for use with Hach's Winkler DO test kit, Model OX-2P (kit, \$14).

(19) "Soil Water Sampler." Soil Moisture Equipment Corp., P.O. Box 30025, Santa Barbara, California 93105 (805) 964-3525.

Company sells several samplers suitable for non-saturated (as well as saturated) sampling of soil water. Both stock and customized lengths from 15 cm. to about 2 m. sizes (\$7-\$10 each). Ceramic cup on bottom of the standard 5 cm. diameter tube. Suction applied via pump (\$7.50) to top of tubes. 1 bar entry valve at the porous cup. Tubes plastic. Large sample possible, taken by pumping.

(20) "Filter Candles." Cole-Parmer Instrument Co., 7425 N. Oak Park Avenue., Chicago, Illinois 60648. (312) 647-0272. Size 25 X 2.4 cm., less tubing.

An inexpensive sampler for subsurface, saturated sampling of soil water inflow of water by gravity into porous cups. About 100 ml. of sample per filling. Polyethylene tubing attached at length desired. Sample removed by a tube attached to vet-medicine size syringe or via other pumping arrangement. \$2.00 each, plus tubing. Have experienced slight inflow of particulate matter in samples, apparently soil, which can be filtered in laboratory.

(21) Note: A variety of "homemade" soil water samplers are commonly devised from perforated drainage pipe and other materials. U.S. Agricultural Research Service references are available on some of these pipes, "lysimeters", and other arrangements.

PART III: HERBICIDE MONITORING GUIDELINES

This section provides some guidelines for use in herbicide monitoring projects. Many of the concepts also are generally applicable to other types of monitoring.

Questions naturally arise when an organization uses herbicides or other toxic chemicals in the natural environment, especially when these substances are released from the air. The public is rightly concerned about possible pollution of water resources and soil, or damage to aquatic and terrestrial organisms. Forest Service professionals share this concern, and the Forest Service will continue to monitor waters for herbicides in conjunction with large or possibly hazardous spray projects. Such surveillance should help insure against unnecessary water pollution, point out hazardous situations, provide information regarding the impacts of herbicide use on water, and finally, supply the data needed to develop guidelines for safe use of these substances (if safe use can be shown possible).

Our field experience in the Eastern Region has demonstrated that the possibility of water contamination exists whenever herbicides are sprayed into forest areas. The opportunity for contamination is normally greatest whenever chemicals are released from aircraft, since drift may occur. In some cases, helicopters cannot avoid flying over open water as flight passes are made. Drip or drain from closed nozzles then may fall directly into the water. (In some of our monitoring situations, such drip apparently occurred.) Herbicides on watershed surfaces are affected by the usual processes of runoff transport, flushing, dilution, and stream loading, as discussed in Part II. Therefore, some of the herbicides likely will appear in waters in and near a spray project area.

Right-of-way spraying offers a particular risk of herbicide impact on water courses. The straight-line nature of powerlines, for example, usually assures that numerous streams will be traversed. Road spraying also presents a hazard in those situations where roads wind along a valley's bottom. Finally, spraying along roads could result in collection and concentration of herbicides during storm runoff, with pollution maximizing at bridges and culverts, where runoff converges.

The concentration of herbicides in water bodies is a function of several factors. High concentrations naturally are more significant than trace amounts. The extent of herbicide concentration in water depends on the proportions of chemicals and dilution water. Therefore, herbicide concentration in streams and ponds is essentially a function of:

1. The rate of herbicide application used on the project.
2. The land areas which are sprayed, whether upland and drained or "runoff source areas," along streams (which are washed during storms). "Sinkholes" are a special problem in karst areas, since they offer direct access to ground water.
3. Accidental drip or drift into water bodies from aircraft.
4. Weather and hydrologic conditions, particularly in regard to storm flushing, droughty, low-flow (hence, minimum dilution) periods, and wind.
5. The soil-vegetation complex at hand and its effect on reducing or enhancing herbicide movement into streams and ponds, either by leaching or surface runoff. Herbicides generally do not move far within the soil; however, "piping" or "secondary porosity" may allow chemicals to find subsurface routes of transport.
6. The amount of time elapsing between herbicide application and the first precipitation.

By understanding the above processes of runoff and stream loading, some general guidelines can be drawn up regarding herbicide monitoring:

1. Where to Monitor - In general, it is advisable to select sampling points where impact is likely to be greatest; for example, points immediately downstream from a timber project spray area. Sampling may include streams, ponds, or potholes with water. In addition to the impact points, control sites may be desired. These control points should be free from any impact from drift, drip, or water flow patterns related to the spraying. If a water supply, say a spring, likely originates in the area of spraying, monitoring the spring may be wise. In ground water sampling, a period of days may be necessary to allow for subsurface travel time. In general, the number of sites should increase with the size of the project, the apparent opportunity for pollution, the hydrologic complexity of the landscape, and the hazard of the chemicals in use. In most cases in the Region for individual timber projects using 2,4-D and 2,4,5-T, we might be able to get by with perhaps two control sites, two sites within the project area, and perhaps two to four downstream sites. Note that the "below" stream monitoring sites should be selected so that incoming side streams do not dilute and mask the impact, thereby not allowing observation of maximum concentrations. To these surface sampling points, we might want to add one or two ground water stations, if a ground water problem is possible.

If several projects are to be monitored simultaneously, it probably will be necessary to settle for fewer sites, perhaps only a single "below" site per project area (for several sites). Of course, a simple, sloped, well-defined watershed is much easier to monitor than a spray area which overlaps two or more catchments and has ill-defined flowage. In the case of road or powerline right-of-way monitoring, there may be a bridge or culvert site where the converging spray effect would be maximized. Such a site would be good for sampling maximum impact. Finally, accessibility of sampling sites must be considered. The "perfect" site simply may be too inaccessible, particularly for storm sampling. Select sites that are reasonably located so that "sampling rounds" can be made quickly enough at critical times. Of course, costs must be considered. Sample analyses are about \$25 each at this time at Madison.

2. Sampling Techniques - The concepts of storm sampling (discussed in Part II) are of primary concern in herbicide sampling. The first storm after spraying, particularly, should be sampled, and ideally, all storms following spraying for about a month should be monitored. The automatic samplers discussed in Part II are especially useful for storms. It is important to sample the early storm runoff, if possible, and particularly to observe concentrations on the rising limb of the storm hydrograph, when surface flushing is greatest. Grab samples should be taken in glass bottles, just below the surface of the water, in a free-flowing area, taking care not to disturb the channel where sampling. For details on sampling preservation and handling, make contact with our consulting chemist in Madison, Jalem Punwar, WARF Institute, P. O. Box 2599, Madison, Wisconsin, 608-257-4851. He will discuss recommendations for shipping, preservation, and other details.

Take particular care that the person sampling has nothing to do with the mechanics of the spray project. He could contaminate all water bottles and samples. Lauterbach (1971) and others warn against this hazard, because of the sensitivity of herbicide analytical methods. Also, watch out for other possible sources of contamination, such as vehicles.

3. Marking Samples/Field Notes - Essentially, such details are a matter of personal preference; however, a few items are essential:

- a. Sample number/site number.
- b. Time of day/date.
- c. Streamflow value or some estimate, and whether stage is rising or falling.
- d. Notes on weather conditions at the time and previous to sampling, depth of rain, temperature, etc.

e. Name of the sampler.

f. Observations on stream turbidity or other related water quality.

g. Water temperature.

h. General comments: "Helicopter just flew over stream", etc.

4. Timing of Collection - Moore (1968) and Lauterbach (1971) recommend (as an example) sampling all sites prior to spraying (for control) then sampling after spraying at 1/4 to 1 hour, 3, 24, 48, and 72 hours, with any storms sampled where possible. Each spray day is considered separately if more than one day is needed to complete the job. Crumrine, on the Ottawa National Forest, recommends sampling several months later as well, to observe any long-term effects, especially during storm runoff. In collecting the first few samples, consider water travel times (which usually can be estimated), as related to the distance from spray site to sampling point. It is especially important to sample sites prior to spraying, for background levels.

5. "Chemical Budgets" - Ideally, a hydrologist would like to be in position to express the herbicide's fate in terms of total kilograms or percentage of the herbicide lost to the water resource. In reality, such a budget is only a rough approximation. A budget can be approached as follows:

a. The discharge from the treated catchment or surface area can be estimated or measured in the field (liters per second runoff). In the case of storm runoff on a small catchment, an approximate area for the runoff contributing surface may be estimated, where the total measured runoff volume in liters (under the hydrograph) is equal to the surface area in square meters times the depth of precipitation falling on this area, in millimeters of rain:

$$\text{liters runoff} = (\text{mm precipitation}) \times (\text{m}^2 \text{ of area})$$

Also, instantaneous runoff in liters per second is approximately:

$$(\text{mm/second rain}) \times (\text{m}^2 \text{ of area}), \text{ on a small area}$$

b. The concentrations of herbicide measured in the stream-flow in milligrams per liter (mg/L) can be expressed in terms of a transport rate, where stream discharge in liters per second times concentration of herbicide in mg/L equals transport rate in milligrams per second.

$$\text{Transport rate in mg/SEC} = (\text{L/SEC}) \times (\text{mg/L})$$

c. Therefore, over a period of time, in seconds or other units, the herbicide passing by can be totalized, where weight of herbicide is summarized with:

$$\text{Herbicide transported in mg} = (\text{mg/SEC}) \times (\text{SEC elapsed})$$

which times 10^6 is simply kilograms of herbicide going past in a given time.

d. In the case of a storm hydrograph, concentrations and discharges both change quickly, so several points of measurement would be necessary to estimate herbicide transport during the storm. Where application rates of the herbicide, runoff areas, concentrations, and discharges can be measured, chemical budgeting concepts are a way to estimate total losses or percent losses of herbicide to the water resource.

e. The hydrologist must recognize that such budgeting can be only a rough approximation, since chemical degradation and certain hydrologic factors cannot be accounted for. Also, determining exact rates of herbicide application input is quite difficult, since drift and other details are involved. Nonetheless, "budgets" can be a useful method of expressing approximate chemical losses and movement on small areas.

6. Other Monitoring - In some situations, the hydrologist should work with fishery biologists or wildlife specialists and assist in other types of monitoring; for example, aquatic organism bioassays or wildlife observations.

7. Reporting - As discussed in the section "Why Monitor?", the results should be presented in interpreted fashion, referring to toxicity, public health, and other data where appropriate. The information gained should be interpreted for guideline use in future projects.

8. References - A few studies have been carried out to monitor herbicides in water. Some references are given in Part V. Also, the hydrologist may wish to subscribe to the Pesticides Monitoring Journal, which includes articles of interest regarding pesticides in the environment. Subscribe to: The Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 - \$1.75 per year.

PART IV

A brief summary of names, formulas, and toxicities for the most commonly used herbicides in the Eastern Region. Details are taken primarily from Pimentel's (1972) and Meister Publishing Company's (1972) manuscripts (see reference list).

Amiben: 3-Amino-2,5-dichlorobenzoic acid (alias chloramben)

Acute oral LD₅₀ (rat), 5620 mg/kg. Persists in soil about 6 weeks to 3 months.

Aminotriazole: (see Amitrole)

Amitrol-T: Mixture of aminotriazole and ammonium thiocyanate (alias Cytrol Amitrole-T, Amitril T.L.).

Amitrole: 3-Amino-1,2,4-triazole (alias aminotriazole, Amrol, ATA, Weedazol, Cytrol)

Acute oral LD₅₀ (rat) 5,000 mg/kg; LD₅₀ (mallards) over 2,000 mg/kg; 48-hour LC₅₀ (salmon) 3,250 ppm. Amitrole applied to water at 1.0 ppm persisted 201 days. May persist up to about 2 months in soil.

Amizine: Mixture of 1 part amitrole, 3 parts simazine.

Ammonium Thiocyanate: NH₄SCN (alias Amthio).

Atrazine: 2-Chloro-4-ethylamino-6-isopropylamino-s-triazine (alias AAtrex, Fenamine, Fenatrol, Gesaprim, Primatol-A, G-30027).

Acute oral LD₅₀ (rat) 3,080 mg/kg; LD₅₀ (mallards) over 2,000 mg/kg; 48-hour LC₅₀ (rainbow trout) 12.6 ppm. Persisted in soil for 17 months, in one study.

Bromacil: 5-Bromo, 3-sec-butyl-6-methyluracil (alias Hyvar X, Hyvar X-P, Hyvar X-L).

Acute oral LD₅₀ (rat) 5,200 mg/kg.

Cacodylic Acid: Dimethylarsinic acid (alias Silvisar 510).

Acute oral LD₅₀ (rat) 1,280 to 1,400 mg/kg; 48-hour LC₅₀ for most fish tested apparently over 500 ppm. Appeared to break down rapidly in the soil in some studies.

Dacthal: Dimethyl tetrachloroterephthalate (alias DCPA, chlorthal-methyl (BSI), DAC 893, Fatal).

Acute oral LD₅₀ (rat) 3,000 mg/kg.

Dalapon and Dalapon-Na: (with sodium) 2,2-Dichloropropionic acid, sodium salt (alias dalapon-Na, Basfapon, Ded-Weed, Dowpon, Gramevin, Radapon, Unipon).

Acute oral LD₅₀ (rat) 7,570 to 9,330 mg/kg; LC₅₀ (mallards) over 5,000 ppm. Dalapon sodium formulation showed 24-hour LC₅₀ (rainbow trout), over 500 ppm and 48-hour LC₅₀ (salmon) 340 ppm. Persists up to about 2 months in soil.

Diuron: 3-(3,4-Dichlorophenyl)-1,1-dimethylurea (alias DMU, DCMU, Marmer, Di-on, Karmex).

Acute oral LD₅₀ (rat) 3,400 mg/kg; LC₅₀ (mallards) over 5,000 ppm. Various stoneflies sensitive, with 24 and 48-hour LC₅₀ from 2 to 4 ppm. The 48-hour LC₅₀ for largemouth bass and coho salmon was 42 and 16 ppm respectively. Crappies killed with as little as 6 ppm diuron. The 48-hour LC₅₀ (rainbow trout) was 4.3 ppm. Persists for several months in ponds and over a year in soil.

Dowpon: (see Dalapon-Na)

Fenuron: 3-Phenyl-1,1-dimethylurea (alias Dybar, fenulon, fenidim).

Acute oral LD₅₀ (rat) 7,500 mg/kg; LC₅₀ (mallards) over 5,000 ppm. Bluegill and smallmouth bass fry survived 10 ppm for 8 days. Persisted about 8 months in soil monitoring.

Hyvar: (see Bromacil)

Monuron: 3(p-Chlorophenyl)-1,1-dimethylurea (alias chlorfenidim, Telvar).

Acute oral LD₅₀ (rat) 3,600 mg/kg; LC₅₀ (mallards) over 5,000 ppm; 48-hour LC₅₀ (salmon) 110.3 ppm. May persist about 3 to 6 months in soil.

Paraquat: 1,1'-Dimethyl-4,4'-bipyridylium ion (alias Gramoxone, Weedol). ("paraquat CL" denotes the dichloride salt and "dual paraquat" the dimethylsulfate salt).

Acute oral LD₅₀ (rat) was 150 mg/kg. The 24-hour LC₅₀ for bluegills to paraquat was 400 ppm. Paraquat persists in pond water up to about 3 weeks.

Picloram: (see Tordon)

Silvex: 2-(2,4,5-Trichlorophenoxy) propionic acid (alias 2,4,5-TP, Fruitone T, Garlon, fenoprop, Kurosai, Kuron). Similar to 2,4,5-T, but apparently more effective in killing oaks.

Silvex (continued):

Acute oral LD₅₀ (rat) 1,070 mg/kg. For mallards, the LC₅₀ was about 4,000 ppm. The LC₅₀ for various fish to silvex is shown in Table 1 on page 24. Silvex apparently persists in soil up to about 3-1/2 months.

Simazine: 2-Chloro-4,6-bis(ethylamino)-s-triazine (alias Princep*, Gesatop, Primatol-S).

Acute oral LD₅₀ (rat) over 5,000 mg/kg; LD₅₀ (mallards) over 5,000 mg/kg; 48-hour LC₅₀ (rainbow trout) from 5 to 56 ppm. Persistent in soil, for over a year in some studies.

Tordon: 4-Amino-3,5,6-trichloropicolinic acid (alias picloram, Borolin).

Acute oral LD₅₀ (rat) 8,200 mg/kg, for young mallards over 2,000 mg/kg. The LC₅₀ for various fish to picloram is shown in Table 2 on page 24. Tordon persists in soil for well over a year.

2,4-D: 2,4-Dichlorophenoxyacetic acid (alias Amoxone, Chloroxone, Crop Rider, Dacamine, Ded-Weed, Esteron, Formula 40, Pennamine D, Salvo, Tributon, Weed-Ag-Bar, Weedone, U46).

This chemical has been greatly studied, and further details on toxicities are available. The LD₅₀ (rat) is about 600 mg/kg, (dog) 100 mg/kg, (mule deer) about 600 mg/kg. LD₅₀ for young mallards over 1,000 mg/kg. The LC₅₀ concentrations for various organisms have been compared to various formulations of 2,4-D (see Table 3 on page 25.) In some cases they vary considerably, as shown in Table 3. To generalize, concentrations of over 5 ppm in water appear to affect fish. 2,4-D persists in ponds or soil for perhaps a month.

2,4,5-T: 2,4,5-Trichlorophenoxyacetic acid (alias Dacamine, Ded-Weed, Brush Killer, Esteron, 245 Concentrate, Fence Rider, Fruitone A, Forron, Inverton 245, Line Rider, Reddon, Verton T).

Like 2,4-D, 2,4,5-T is receiving much research at this time. The LD₅₀ (rat) was 300 mg/kg, for dogs 100 mg/kg, for mallards over 5,000 ppm. Various formulations of 2,4,5-T vary in respect to toxicity (see Table 4 on page 25 for further details). 2,4,5-T may persist in soils for about 3 months.

Table 1. The LC₅₀ for Various Fish to Silvex 1/

Formulation	Fish Species	Exposure Time (hr)	LC ₅₀ (ppm)	Source
Acid	Bluegills	18	70	Cope, 1963
Acid	Bluegills	¹ 24	2.9	Surber & Pickering, 1962
Acid	Fathead minnow	¹ 24	8.9	"
Acid	Bluegills	24	19	Cope, 1965a
Acid	Rainbow trout	24	23	"
Acid	Harlequin fish	24	48	Alabaster, 1969
Acid	Bluegills	48	0.60	Bohmont, 1967
PGBEE ²	Rainbow trout	48	0.650	FWPCA, 1968
BEE ³	Bluegills	48	1.2	"
Acid	Salmon	48	1.23	Bohmont, 1967
Isooctyl	Bluegills	48	1.4	FWPCA, 1968

1 Softwater.

2 Propylene glycol buytl ether ester.

3 Butoxyethanol ester.

Table 2. The LC₅₀ for Various Fish to Picloram 2/

Formulation	Fish Species	Exposure Time (hr)	LC ₅₀ (ppm)	Source
Acid	Fathead minnow	24	64	Weimer, et al., 1967
Potassium salt	Harlequin fish	24	66	Alabaster, 1969
Acid	Fathead minnow	24	135	Lynn, 1965
Acid	Rainbow trout	24	150	Weimer, et al., 1967
Acid	Green sunfish	24	150	"
Acid	Brown trout	24	230	"
Acid	Rainbow trout	24	230	Lynn, 1965
Acid	Brown trout	24	240	"
Acid	Brook trout	24	240	Weimer, et al., 1967
Acid	Brook trout	24	420	Lynn, 1965
Acid	Green sunfish	24	420	"
Acid	Black bullhead	24	420	"
Acid	Rainbow trout	48	2.5	FWPCA, 1968

1/ Table from Daniel Pimentel, 1971 (see references).

2/ Ibid.

Table 3. The LC_{50} for Various Fish to 2,4-D 3/

Formulation	Fish Species	Exposure Time (hr)	LC_{50} (ppm)	Source
Butyl Ester	Harlequin fish	24	1.0	Alabaster, 1969
Oleic-1,-propylene diamine	Bluegill	24	4.0	Davis and Hughes, 1963
Butyl Ester	Bluegill	24	4.9	"
Butyl Ester	Bluegill	24	10	"
	Rainbow trout	24	250	Alabaster, 1956
Amine	Rainbow trout	24	250	Alabaster, 1969
Ethylhexy Ester	Lake Emerald shiner	24	280	Swabey and Schenk, 1963
Ethylhexy Ester	Lake Emerald shiner	24	620	"
Sodium Salt	Harlequin fish	24	1,160	Alabaster, 1969
Isopropyl	Bluegill	48	0.8	FWPCA, 1968
Propylene Glycol Butyl Ether Ester	Rainbow trout	48	0.96	"
	Rainbow trout	48	1.1	Bohmont, 1967
Butyl Ester	Bluegill	48	1.3	FWPCA, 1968
Mixed Butyl and Isopropyl Esters	Bluegill	48	1.5	"
Butoxyethanol Ester	Bluegill	48	2.1	"
	Bluegill	48	3.7	Bohmont, 1967

Table 4. The LC_{50} for Various Fish to 2,4,5-T 4/

Formulation	Fish Species	Exposure Time (hr)	LC_{50} (ppm)	Species
Butyl ester	Harlequin fish	24	1.0	Alabaster, 1969
Isopropyl ester	Bluegill	24	1.8	Davis and Hughes, 1963
Oleic-1,3-propylene diamine	Bluegill	24	2.9	"
Acid	Rainbow trout	24	12	Alabaster, 1956
Triethylamine	Bluegill	24	53.7	Davis and Hughes, 1963
Acid	Bluegill	48	0.50	Bohmont, 1967
Propylene glycol butyl ether ester	Bluegill	48	0.56	FWPCA, 1968
Acid	Rainbow trout	48	1.3	Bohmont, 1967
Isopropyl ester	Bluegill	48	1.7	FWPCA, 1968
Isooctyl ester	Bluegill	48	16.7	"

3/ Table from Daniel Pimentel, 1971 (see references).

4/ Ibid.

PART V

A brief review of literature relating to water monitoring for herbicides. Summary and comments on several articles of general interest and possible application.

Section 1 Water Monitoring

Section 2 Toxicity and Chemical Information

Section 3 Philosophy of Herbicide Use: Advantages and Hazards

Section 4 Other References of Possible Interest

SECTION 1
WATER MONITORING

Brown, E. and Y. A. Nishioka. 1967. Pesticides in selected western streams - a contribution to the national program. Pesticide Monitoring Journal 1(2): 38-48. A report on the monitoring of pesticides in western U.S. streams, including observations of 2,4-D, 2,4,5-T, and Silvex. No 2,4-D or other herbicides were observed at anytime at any monitoring station, indicating that the herbicides were either degraded rapidly, greatly diluted, or did not attain the stream. In areas of heavy 2,4-D use, degradation must be occurring. Some discussion is made of sample handling.

Crumrine, John. 1971. (unpublished) Water monitoring program for 1971 aerial spraying: Ottawa National Forest. In letter to RO from SO, 18 Oct. 1971, 2470, Silvicultural Practices, Harn, J. H. 3 p. report plus tables. Description of 2,4-D and 2,4,5-T monitoring at a spray site, where stream, well and standing water were analyzed. Data indicated only small effect of the herbicides on the water resources at the site, in terms of concentrations in water or duration of the chemicals in streams.

Davis, E. A., P. A. Ingebo, and C. P. Pase. 1968. Effect of a watershed treatment with picloram on water quality. U.S. Forest Service Research Note RM-100. Brief study indicates possibility of picloram contamination of stream following spraying, given certain situations.

Douglass, J. E. et al. 1969. Low herbicide concentration found in streamflow after a grass cover is killed. U.S. Forest Service Research Note SE-108. SEFES, Asheville, N. C. 3 pp. Study indicates no water pollution hazard to stream after spraying, if buffer strip is left unsprayed along the stream.

Frere, M. H. 1971. Requisite sampling frequency for measuring nutrient and pesticide movement with runoff waters. Journal Agr. Food Chem. 19(5):837-9. (Frere is at the U.S. Soils Laboratory, U.S. Dept. of Agr., Plant Industry Station, Beltsville, Maryland, 20705.) The paper looks at samples in waters running off agricultural lands. Concentrations of various constituents in storm runoff may vary greatly - as much as 100-fold - from one storm to another. Within each storm there is variation as well. Two references.

Lauterbach, P. G. et al. 1971. Forest chemical monitoring. A report by Forest Chemical Monitoring Subcommittee of the Forestry Chemicals Committee, Northwest Pest Action Council, Dec., 1971. Weyerhaeuser Company, Tacoma, Washington, 98401. 12 pp. (Offset manuscript.) The report lists the committee's recommendations for monitoring a forest spray project. Much of the report discusses the philosophy of monitoring (as viewed by the Committee); however, there also are some useful technical guidelines in the report. The three pages on timing and siting of sampling are a good summary and the page on fish sampling is useful.

Norris, L. A. 1969. Herbicide runoff from forest lands sprayed in summer. Reprint from U.S.F.S., Oregon State University, Corvallis. 2 pp. Some data are given on concentration and runoff of 2,4-D and picloram during several storms sampled.

Norris, L. A. and D. G. Moore. 1970. The entry and fate of forest chemicals in streams. Proceedings, A Symposium Forest Land Uses and Stream Environment, October 19-21, 1970, Oregon State University, (reprint). pp. 138-158. A summary of several topics: degradation, drift, mobility, monitoring, etc., summarizing much of Norris' and Moore's earlier work. Also considers forest fertilization and stream enrichment. Good list of references (82).

Marston, R. B. et al. 1968. Amitrole concentrations in creek waters downstream from an aerially sprayed watershed sub-basin. Pesticides Monitoring Journal 2(3): 123-128. Describes water sampling schedule and observed concentrations of herbicides at different points on and around a municipal watershed in Oregon. The spraying was on 100 acres. Measurable amounts of herbicides were observed during spraying and for 5 days thereafter. The maximum concentration (155 ppb) occurred during spraying. Some description also given on techniques of sampling, analysis, and other items. Apparently very thorough study.

McKee, J. E., and H. W. Wolf. 1963. Water Quality Criteria (2nd ed.). State Water Quality Control Board, California. Publ. No. 3-A. Sacramento. 548 pp. 3821 references. A very excellent, although slightly outdated reference containing information on thousands of chemicals, including pesticides. Reportedly a revised version is soon to be available. (The RO has inquired about purchase of same for all the Forests.) Similar, more recent data on herbicides are found in Pimentel's review (see description).

Moore, D. G. 1968. Principles of monitoring. pp. 155-168. In "Pesticides, pest control and safety on forest and range lands." Cappizzi and Witt (eds.), Oregon State University, Corvallis. Discusses development of a monitoring design on the Burns Tussock Moth Control Project in Oregon (1965), carried out by USFS, as example of monitoring. Evaluates concentrations of 2,4-D in stream from less than one to 115 hours after spraying. Notes importance of not spraying streams per se. Discusses sampling timing, procedures, transport, storage, compositing, safety, and other aspects.

Osborne, J. M. 1971. (unpublished report) Herbicide monitoring report for the Chippewa National Forest. Report prepared on the Forest by Osborne, 13 pp. Results of the 1971 season of spraying and monitoring where 2,4-D and 2,4,5-T were applied by helicopter at one pound acid equivalent (each, of D and T) per acre, on a 150 acre site. Osborne describes the sampling, analytical results, costs, and gives his interpretations. The concentrations found were very low; however, some herbicides apparently reached the stream following a rain storm. He notes the need to sample both before and after spraying, with consideration of storms.

Sears, H. S. and W. R. Meehan. 1971. Residues in fish, wildlife, and estuaries. Pesticides Monitoring Journal. 5(2):213-217. Measurements below an area sprayed with 2,4-D in Southeastern Alaska showed no immediate mortality to aquatic organisms observed. The study was based on only four (4) actual chemical measurements of water. Also, control sampling and other water resource aspects of the study were very limited. (Reprinted by USFS for public distribution.)

Sheets, T. J. and J. F. Lutz. 1969. Movement of herbicides in runoff water. Presentation at American Society of Agricultural Engineers meeting, December, 1969, Chicago. Copy from Sheets at Pesticide Residue Research Laboratory, N. C. State University, Raleigh, N. C. 8 pp. Small watersheds of 3-5 acres were observed, using 2,4-D, 2,4,5-T, picloram, and dicamba. Storm runoff samples were gathered. Soil samples were taken. Application rates were 2 lb/acre. The results showed that "low concentrations of 2,4-D, 2,4,5-T, and picloram appear in runoff water from watersheds sprayed at rates needed for herbaceous weed and woody plant control." "The concentrations in the water vary directly with the rate of application and percent of the area sprayed." Data are given for concentrations. 2,4-D in storm runoff attained up to 1224 ppb, 2,4,5-T up to 583 ppb, and picloram up to 299 ppb when 2 lb/A was applied.

Tarrant, R. F. 1966. Pesticides in forest waters - symptom of a growing problem. Proceedings, Society of American Foresters, Seattle, Washington 1966. pp. 159-163. A general description of pesticide use and pollution potentials on forest lands of the country.

Tarrant, R. F. and L. A. Norris. 1967. Residues of herbicides and diesel oil carriers in forest waters: A review. pp. 94-102, In Symposium Proceedings: Herbicides and vegetation management in forests, ranges, and noncrop lands, 1967, Oregon State University. (Reprint available from U.S. Forest Service, O.S.U., Corvallis, Oregon, Mrs. Knutson, Librarian.) "A Summary of evidence from research indicates that many herbicides and their carriers, when used in a responsible manner, can be employed in forest vegetation control with minimum impact on water quality," according to the authors' interpretation. Review includes about 30 pertinent references, primarily from the U.S. Forest Service, the State of Oregon, and Germans who have investigated movement of diesel oil in soils and water.

U.S. Department of Interior. 1968. Water quality criteria: report of the National Technical Advisory Committee to the Secretary of the Interior. April 1, 1968. Washington. 234 pp. This book should appear in revised form sometime in 1972. There are a number of important tables on allowable chemical levels, for example, herbicides in waters. Forests should obtain the revised versions as soon as possible, as major changes allegedly are likely in certain instances.

Wojtalik, T. A., T. F. Hall, and L. O. Hill. 1971. Monitoring ecological conditions associated with wide-scale applications of DMA 2,4-D to aquatic environments. Pesticides Monitoring Journal 4(4): 184-203. Report on use of herbicides for Eurasian water mulfoil control on Tennessee Valley Authority reservoirs. A rather detailed limnological and biological survey of the herbicide effects, which reportedly were negligible. Also a large number of water samples were tested. Of particular interest from a chemical viewpoint are the supplements on analytical techniques, which are quite specific. Perhaps the largest monitoring project yet conducted. Showed 2,4-D not to be cumulative in the food chain or food webs.

SECTION 2
TOXICITY AND CHEMICAL INFORMATION

Environmental Protection Agency (continuing) Health aspects of pesticides: abstract bulletin. A quarterly abstract to "foster current awareness ... of ... effects of pesticides on humans." Abstracts come from over 500 domestic and foreign journals. Subscription available from Superintendent of Documents, Washington, D. C. 20402. Order HAPAB, \$6.50 per year, also including annual index. Perhaps 150-200 abstracts per issue. Also includes field studies, for example, agricultural runoff plot measurement.

Arthur D. Little, Inc. 1970. Water quality criteria data book Vol. I: organic chemical pollution of fresh water. (Copy ordered by R.O.) Reportedly an updating of the McKee and Wolf "bible" of water quality criteria (see reference to same). Work contracted for E.P.A.

Meister Publishing Co. 1972. Farm Chemicals Handbook: 1972. 666 pp. Available from Meister Publishing Co., 37841 Euclid Avenue, Willoughby, Ohio, 44094, \$17.50/copy. A good summary of the chemical names, formulations, descriptions, uses, and other details. Some references to toxicities. Commercial names summarized. Covers chemical preparation and chemical mixing. Not much ecological information as such. Lists sources of equipment and supplies.

Norris, L. A. 1971. Chemical brush control: assessing the hazard. *Journal of Forestry* 69(10): 715-720. Considers 2,4-D, 2,4,5-T, amitrole, and picloram in terms of toxicity, persistence, and degradation on forested sites. Norris concludes that "proper use" of the above herbicides presents "no hazard" on forest lands.

Pimentel, David. 1971. Ecological effects of pesticides on non-target species. Report to Executive Office of the President, Office of Science and Technology, June 1971. (Superintendent of Documents Stock No. 4106-0029; \$2.00.) Dr. Pimentel is at Dept. of Entomology and Limnology, Cornell University, Ithaca, N.Y., 220 pp. Probably the most recent, complete survey of this type at the present time. Many chemicals are considered, tables of concentrations are shown, and studies are discussed briefly.

Thomson, W. T. 1970. Agricultural chemicals - Book II: Herbicides. 251 pp. A use manual for various herbicides, containing details on preparation, formulations, precautions, etc.

SECTION 3

Philosophy of Herbicide Use: Advantages and Hazards

Aley, Thomas. 1970. (unpublished) An adverse impacts analysis of herbicides, particularly 2,4,5-T and 2,4-D, Mark Twain National Forest. Mimeograph, rather detailed report of 17 pp., including 29 references, up to 1969. Report summarizes adverse effects that can result from herbicide use, considering human health, wildlife, and other biological aspects. Also considered are effects of herbicides on domestic water supplies. Copies possibly could be obtained by contacting author, on the Mark Twain.

Epstein, Samuel S. 1970. A family likeness. Environment: July-Aug. 1970: 16-25. Epstein is Chief of the Laboratories of Environmental Toxicology and Carcinogenesis at the Children's Cancer Research Foundation, Inc., Boston. This article is based on Dr. Epstein's testimony on "Teratogenic Effects of 2,4,5-T Formulations", before the Senate Subcommittee on Energy, Resources, and the Environment, Committee on Commerce, April 15, 1970. Stresses concern over use of 2,4-D and 2,4,5-T and notes that these chemicals should be further investigated. Notes that the isooctyl, butyl, and isopropyl esters of 2,4-D have been shown to cause birth defects in mice (only the ethyl ester did not). Also, he notes that in the 2,4,5-T samples, a contaminant, tetra dioxin, also might be responsible for the birth defects. Notes further tests with "pure" samples, however, likewise produced significant number of defects. Points out that humans were found to be 700 times more sensitive to thalidomide than were hamsters, a consideration he feels is of vital concern in evaluating any test-animal teratogenicity data.

Galston, A. W. 1970. "Rebuttal to the Newton-Norris note 'herbicide usage', which appeared on preceding page." Author believes we should not sanction the use of phenoxy herbicides at the time of his writing. He feels more information should be gathered on the possible teratogenicity of 2,4,5-T; meanwhile its use should be suspended. In his opinion, "Must we wait for definite proof of an abnormal birth before we are prepared to act?" Author is at the Department of Biology, Yale University, New Haven.

Howard, Benton. 1970. The Forest Service and Herbicides. Technical Bulletin, USFS, Pacific Northwest Region. 39 pp. This report summarizes work by Norris and other Forest Service workers, primarily. References are mostly from industry and USDA. Interpretations drawn view herbicides as "safe" to use on forest lands.

Johns, H. R. 1970. Effects of herbicides on the environment. Reprint from Transmission and Distribution Committee, Edison Electric Institute. 12 pp. Author is with Asplundh Tree Expert Co. He makes "case" for the use of 2,4,5-T by pointing to evidence that in his opinion proves complete safety of the chemical. He highly recommends herbicide use as a management tool.

Newton, Michael and L. A. Norris. 1970. Herbicide usage. Science 168:1606. The authors maintain that "our studies of normal use of herbicides in Pacific Northwest forests indicate that further restrictions on these uses of the phenoxy herbicides are not justified." Authors wish to use herbicides for management purposes.

President's Science Advisory Committee. 1971. A report of the panel on herbicides of the President's Science Advisory Committee: Report on 2,4,5-T. 68 pp. Superintendent of Documents. 40 cents. The panel "found evidence of measurable benefits from the use of 2,4,5-T but there was simply very little information that could be used to assess risk," according to the chairman of the Committee, E. E. David, Jr. The report reviews and discusses the chemistry of 2,4,5-T, its use, toxicology, and looks at the questions of residues and various possible "side effects". (A summary of much of what is known to date about the chemical.)

Reigner, I. C., W. E. Sopper, and R. R. Johnson. 1968. Will the use of 2,4,5-T to control streamside vegetation contaminate public water supplies? Journal of Forestry 66(12):914-918. Study indicates only "slight contamination" within treated sections of streams immediately after spraying with 2,4,5-T. Report encourages the use of herbicides on municipal catchments, since levels in runoff were found low in studies conducted. The hazards of the chemicals are not considered significant by the author.

Smith, Gordon E., and B. G. Isom. 1967. Investigation of effects of large-scale applications of 2,4-D on aquatic fauna and water quality. Pesticides Monitoring Journal 1(3): 16-21. Includes 2 references. Summarizes TVA studies on use of 2,4-D on Eurasian water milfoil growths in reservoirs in 1966. Interpretations are made that the treatment had no "adverse effect on aquatic fauna or water quality." Tables of data included. Authors are at Division of Health and Safety, TVA, Muscle Shoals, Ala. 35660.

Sterling, T. D. 1971. Difficulty of evaluating the toxicity and teratogenicity of 2,4,5-T from existing animal experiments. Science 174:1358-59 (24 Dec. 1971). The author makes the point that toxicity and teratogenic studies of 2,4,5-T are inadequate to date. All experiments have tested the effect of 2,4,5-T at high doses on a few animals, whereas there has been no adequate testing of low dose effects. The manuscript also notes the difficulty of extrapolating animal results to human; for example, rats are many times more tolerant to 2,4,5-T than dogs, yet most inferences about toxicity of 2,4,5-T to man are based on work with rodents. He disagrees that 2,4,5-T has been proven "safe".

Whiteside, Thomas. 1970. Defoliation. A Ballantine/Friends of the Earth Book (paperback). 169 pp. with index. Discussion of the politics of herbicide use, particularly as related to the military. Emphasizes that because of vested interest groups it has been difficult to get the facts on herbicide hazards. Whiteside believes the hazards of 2,4-D and 2,4,5-T have been underrated. Points out that 2,4,5-T, according to Bionetics Research studies, may produce teratogenic effects, even at lowest levels. Discusses the problem of dioxin contamination in 2,4,5-T. Includes in appendix: excerpts from Bionetics Report, a HEW committee report, several statements by politicians, and several excerpts from military documents. Whiteside is a journalist, summarizing reviewed literature.

Wilson, J. G. (Chairman) et al. 1971. Report of the Advisory Committee on 2,4,5-T to the Administrator of the Environmental Protection Agency, May 7, 1971. (Mimeo) 75 pp. A study of the possible health hazards of 2,4,5-T. Considers risks vs. benefits of use of the chemical in terms of chronic toxicity, mutagenicity, and carcinogenicity. Study notes that 2,4,5-T samples in runoff studies usually have shown very low concentrations and do not persist. Study concluded that 2,4,5-T is rapidly excreted in animals, not accumulated. Report points out information on the teratogenic and embryo-lethal effects of T. One committee member notes that the data used were not sufficient to answer questions about 2,4,5-T long term hazards and that many of the studies used as evidence were not well controlled or very thorough.

SECTION 4
OTHER REFERENCES OF POSSIBLE INTEREST

Bramble, W. C. and W. R. Byrnes. 1967. Ecological aspects of brush control - a long term study on a utility right-of-way. Purdue University Research Bulletin No. 835. Agricultural Experiment Station, Lafayette, Indiana. 12 pp. An interesting study of the plant species composition evolving over a period of years along a sprayed powerline right-of-way in central Pennsylvania. (Bramble is head of the Forestry Department at Penn State.) Details given on the plant communities, wildlife, game usage of the areas, given various spray treatments.

Cravens, J. H. 1970. (unpublished) Interim guidelines for the use of herbicides. 11 pp. plus refs. (Reply to: 5200, letter Dec. 31, 1970, to Forest Supervisors.) Summarizes impacts of phenoxy herbicides on soil, organisms, esthetics, human health, and wildlife.

Hammond, A. L. 1972. Chemical pollution: polychlorinated biphenyls. Science 175:155-156 (14 Jan. 1972). PCB's are increasingly found in rainwater, human tissue, and wildlife, and apparently are becoming widespread in the environment, as discussed by the article. Whether these chemicals will be of importance on a Forest may depend on the proximity of industry; however, water scientists may hear questions on PCB's in the natural environment.

Norris, L. A. 1970. Degradation of herbicides in the forest floor. Tree Growth and Forest Soils. pp. 397-411. (U.S. Forest Service Reprint, PNWFRES). Discusses degradation of 2,4-D; 2,4,5-T, amitrole and picloram in forest litter, showing percent recovery curves. (Norris is at Forestry Science Lab., Corvallis, Oregon; reprints available.) Rather detailed, good research on this aspect.

Svenson, H. A. 1966. Vegetation management for rights-of-way. Bulletin, U.S. Forest Service, Eastern Region. 38 pp. Discussion of plant species used in rights-of-way, methods of managing these areas, some history of herbicide use in Region 9, and other information along these lines.

Wernham, J. O. Oct. 22, 1971. (unpublished) Letter to Division Timber Management; Reply to 1940, Regional Office. Attached list describes use of herbicides in recreation and wildlife management; openings, grass, browse, aquatic plants, rights-of-way, and poison ivy control.

Woodwell, G. M., P. P. Craig, and H. A. Johnson. 1971. DDT in the biosphere: Where does it go? Science 174: 1101-7. Discussion of global modeling to appraise the hazards of DDT residues in the biosphere. Of general interest in reference to pesticide accumulation, drifting, and residues. Residues appear to move from the land through the atmosphere into the oceans. Concentrations in the atmosphere and in the mixed layer of the oceans lag by a few years behind the amounts of DDT used annually throughout the world. There are 62 references. (These questions of drift, residues, and food chain concentration are of importance in evaluating herbicide use on forest lands where water resources are involved.)

APPENDIX I

GLOSSARY OF TERMS

Taken from "A guide to the practice of chemical brush control on the Suislaw National Forest," Corvallis, Oregon, December 1971, by Norman L. Adams.

Acid equivalent. The theoretical yield of parent acid from an active ingredient, on a per gallon basis, i.e. 4 lbs. a.e. yields 4 lbs. of active acid per gallon of solution. Not applicable to all herbicides, e.g. amitrole and atrazine.

Active ingredients. The chemicals in a product that are responsible for the herbicidal effects.

Annual. A plant that completes its life cycle from seed in one year.

Band application. An application to a continuous restricted band such as in or along a crop row, rather than over the entire field area.

Basal-bark treatment. Herbicide treatment applied to the stems of woody plants at and just above the ground.

Biennial. A plant that completes its life cycle in two years. The first year it produces leaves and stores food. The second year it produces fruits and seeds.

Broadcast application. An application over an entire area.

Broad-leaved plants. Botanically, those classified as dicotyledons. Morphologically, those that have broad, often compound, leaves.

Brush control. Control of woody plants.

Carrier. The liquid or solid material added to a chemical compound to facilitate its application.

Compatible pesticides. Compounds or formulations which can be mixed and applied together without undesirably altering their separate effects.

Concentration. The amount of active ingredient or acid equivalent on a given volume of liquid or in a given weight of dry material.

Contact herbicide. A herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.

Deciduous trees. Those that lose their leaves during winter.

Defoliator or Defoliant. A compound which causes the leaves or foliage to drop from the plant.

Desiccant. A compound that promotes dehydration of plant tissue.

Directed application. An application to a localized area, such as a row or bed at the base of plants.

Dormant. State of inhibited growth of seeds or other living plant organs due to internal causes.

Dormant Spray. A herbicide applied during the period after leaf-fall or death of leaves and before bud break of evergreen trees.

Emulsifying agent. A surface active material which facilitates the suspension of one liquid in another.

Emulsion. The suspension of one liquid as minute globules in another liquid; for example, oil dispersed in water.

Epinasty. Increase growth on the upper surface of a plant organ or part (especially leaves) causing it to bend downward.

Ester. Formed by the reaction of the herbicide acid, such as 2,4-D plus an alcohol. This reaction takes place with heat, pressure, and in the presence of a catalyst, and is known as esterification.

Foliage application. An application of a herbicide to the foliage (leaves, stems, shoots) of a plant.

Foliar spray. A herbicide applied after bud burst, when plants are in full leaf.

Formulation. A term used synonymously with product. It contains the herbicide in a form that can be (1) dissolved or suspended in a carrier and distributed in solution or suspensions by sprayer; (2) distributed dry by dusters or spreaders; or (3) easily vaporized for fumigation.

g.p.m. Gallons per minute.

Growth regulator. An organic substance effective in minute amounts for controlling or modifying plant growth.

Hazard area. An area outside of treated area that is susceptible to contamination and damage from the chemical used, i.e. private owner-ships, critical watersheds, established plantations, open streams, etc.

Herbaceous plant. A vascular plant that does not develop wood tissue.

Herbicide. A chemical used for killing or inhibiting growth of plants.

Invert emulsion. Water in oil emulsion rather than the more familiar oil-in-water emulsion. Such emulsions produce larger, heavier droplets of spray than standard water, oil or oil-water sprays. This allows greater control of spray drift with aerial applications. The increased viscosity of the invert emulsion requires specialized application to handle the thick material.

Ionic surfactant. One that ionizes or dissociates in water.

Leaching. Movement of a substance downward through the soil.

L.D.₅₀. Single dose in milligrams of chemical per kilogram of body weight lethal to 50% of the animals tested.

Low volatile ester. Chemically, an ester prepared with a heavy, molecular weight, alcohol such as the butoxy-ethanol, iso-octyl, or propylene glycol butyl ether esters. Biologically, an ester that is less likely to injure plants by vapor activity than a high-volatile ester.

Nonionic surfactant. One that does not ionize or dissociate in water.

Nonselective herbicide. One that is toxic to all plants.

Noxious weed. A plant defined by law as being especially undesirable, troublesome, and difficult to control. Definition of the term "noxious weed" will vary according to legal interpretations.

Perennial. A plant that lives for more than two years.

Pesticide. Any substance used to kill undesirable plants, insects, animals, and other organisms.

pH. The chemist's measure of acidity and alkalinity. It is a scale in which the figure 7 indicates neutral, figures below 7 indicate acidity, and figures above 7 indicate an alkalinity.

Phytotoxic. Poisonous to plants.

Post burn. Any time after burning of an area.

Post emergence. After emergence of specified week or crop.

p.p.m. Parts per million.

Preburn. Any time before area is burned.

Pre-planting. Any time before the area is planted with the desired species.

p.s.i. Pounds per square inch.

Rate. The weight of active ingredient or acid equivalent of a herbicide or volume of carrier applied to a unit area. (Usually expressed in lbs. of herbicide in gallons of carrier per acre.)

Release spray. A herbicide applied to forest plantations which are overcome with competitive brush species; the objective is to kill or retard the growth of such competitive vegetation and accelerating the growth of desirable conifers.

Selective herbicide. A herbicide that will kill some plant species when applied to a mixed population without serious injury to other species.

Soil sterilant. A herbicide that prevents the growth of plants when present in the soil. Soil sterilization may be temporary or relatively permanent.

Spray drift. The movement of airborne spray particles from the intended area of application.

Spreader-sticker. A surfactant closely related to wetting agents that facilitates spreading and increases sticking of a herbicide on vegetation.

Surfactant. A material which facilitates, and accentuates, the emulsifying, dispersing, spreading, wetting, and other surface-modifying properties of herbicide formulations.

Suspension. A system consisting of very finely divided solid particles dispersed in a solid, liquid, or gas.

Synergism. Cooperative action of different chemicals such that the total effect is greater than the sum of the independent effects.

Translocated herbicide. Herbicide movement within the plant from the point of entry.

Vapor drift. The movement of herbicidal vapors from the sprayed area.

Volatility. The evaporation or vaporization (changing from a liquid to a gas) at ordinary temperatures on exposure to the air.

Weed. A plant growing where it is not desired (Siuslaw brush).

Weed control. The process of limiting weed (brush) infestation so that crops (coniferous trees) can be grown without or with less competition for soil nutrients, water and sunlight; an area treatment of weeds (brush) with the objective of producing a crop of trees at the earliest possible time by reducing and/or eliminating competition from undesirable vegetation.

Wetting agent. An additive compound in spray solutions causing larger coverage of plant surfaces by reducing surface tension, i.e. a surfactant.

APPENDIX II

SUMMARY OF 1971 PROJECTS

In 1971, two of the Forests in Region 9 monitored water quality in conjunction with aerial herbicide applications of 2,4-D and 2,4,5-T. The monitoring provided quantitative data on herbicide flushing into streams and other waters in and around the spray site. The results of these two projects are presented briefly here. More details are available from the hydrologists who carried out the work: John Osborne on the Chippewa, and John Crumrine on the Ottawa.

On the Ottawa National Forest aerial applications were applied at rates of one pound per acre for 2,4-D and two pounds for 2,4,5-T. Samples of water were gathered before spraying, immediately after, three hours after, and about one day later, following rain (an intense storm of about one inch).

The storm runoff carried low concentrations of herbicides into standing water within the spray area and also into a stream below the spray site. Concentrations of the herbicides in standing water within the spray boundary were up to 38 micrograms per liter (38 ppb) following the storm. The stream below the spray site showed no detectable 2,4-D while concentrations of 2,4,5-T were as high as 0.8 micrograms per liter (0.8 ppb), showing that some herbicide was washed into the stream. These concentrations were quite low in terms of existing toxicity data on organisms, as provided by bio-assay research. Crumrine also sampled three of the sites 40 days after spraying on the Ottawa and found no detectable levels of herbicides in streams. The swamp water within the control spray area still showed 10.3 ppb.

On the Chippewa National Forest, standing water in potholes (6 to 10 meters across and 1 to 2 meters deep) was sampled. Water in plastic pans placed in the project also was monitored, as well as a nearby creek. Osborne sampled before spraying, immediately after, 4 hours after, and after two separate storms (within a few days following sampling). Concentrations in the potholes were 160 ppb for 2,4,5-T, following spraying, and 50 ppb for 2,4-D. In the stream, concentrations were highest following a rain a few days after spraying, when 2,4-D was 5 ppb and 2,4,5-T was 3.3 ppb. Low background levels also appeared in the stream and potholes prior to spraying (a fact which may simply reflect the lower limit of analytical detectability rather than "residuals," since no herbicides have been used on the area for several years).

As Osborne notes, Chippewa concentrations were low enough to not likely be of concern in terms of the biological community of the water sampled. Crumrine makes the same observation. At the same

time, low concentrations of these chemicals were nonetheless found in the stream and standing waters at and near both spray projects.

These two monitoring projects produced results comparable to those from several such projects in the Northwestern United States, showing that if certain precautions are taken, herbicide levels in streams near spray forest projects generally remain low. However, some water contamination does occur.

If the Forest Service continues to use these chemicals in the natural environment, it is imperative that we maintain careful control over their use and develop safe guidelines for usage. Water monitoring is very much a part of this environmental control and guideline testing.

-Kunkle

APPENDIX III

Controls on Herbicide

A Summary by
Jay R. Law^{1/}

All proposed uses of pesticides (herbicides included) are submitted prior to start of the fiscal year by the District Ranger through the individual Forest Pesticide-Use Coordinators and then to the Regional Chemical Use Committee. The Regional Committee is appointed by the Regional Forester and currently consists of a Division of Timber Management staff forester, a wildlife biologist, a water quality scientist, and staff specialists representing the Branch of Environmental Engineering, and Divisions of Forest Fire Control and Air Operations, and Information and Education. Liaison between this group and the Regional Forester is maintained through the Assistant to the Regional Forester. The Committee is responsible for reviewing all chemical uses proposed for National Forest lands to assure compliance with National Policy, Regional and Service-wide guidelines and registration restrictions. Those chemical uses requiring further review by the Working Group on Pest Management of the President's Council of Environmental Quality and the Pesticide Use Coordinating Committee (Forest Service) are forwarded to the Washington Office level.

Guidelines for Forest Service Use of Pesticides

The Secretary's Memorandum No. 1666 establishes the USDA policy on pesticides. In part, this policy is to "encourage the use of those means of effective pest control which provide the least potential hazard to man, his animals, wildlife, and the other components of the natural environment.....Where chemicals are required for pest control, patterns of use, methods of application and formulations which will most effectively limit the impact of the chemicals to the target organism shall be used and recommended."

^{1/} Chairman, Region Nine Chemical Use Committee May 8, 1972.

Consistent with Departmental policy, continued Forest Service use of pesticides observe the following procedure in processing proposals:

Proposal Submission

Forest Service pesticide-use proposals which fall into one or more of the following categories require Working Group on Pest Management review:

- usage of a pesticide that is not registered under the Federal Insecticide, Fungicide, and Rodenticide Act for that particular purpose or in that particular way
- uses of any of the compounds contained in the "List of Pesticide Usages of Special Interest to the Working Group," except termite control in interior use provided registered directions on labels are followed
- any use that would be applied to water or might be expected to get into water
- any program or project in which 100 or more contiguous acres would be treated as one application
- use of pesticides in a federal installation when that usage is not under the direct supervision or on-site responsibility of a federal employee trained in the safe and effective use of the pesticide involved.

Regional Foresters and Area and Station Directors submit all pesticide-use proposals included in the above categories for the ensuing fiscal year to the Washington Office by March 1 annually.

During 1970 the Region delayed all aerial and mist blower application of herbicides for the purpose of further evaluating the impact of these chemicals on the environment, and to learn more about application equipment and methods which would assure more positive placement of the herbicides on the target areas. Following a format similar to an Environmental Statement, a careful review was made of the Region's use of phenoxy herbicides and aerial and ground applications. The Interim Guide based on this study was made effective on December 31, 1970.

Interim Guidelines for the Use of Herbicides

Only registered herbicides will be used in our program and only for registered uses as described on the label. They will be applied in accordance with label directions.

Each proposed herbicide project will be based on a prescription for treatment that evaluates and justifies the need for the treatment and considers the benefits and possible adverse effects on the environment.

Only those application methods that assure positive placement of the herbicide on the target area or pest will be used. This precludes the use of materials or methods that cause appreciable drift or volatilization beyond the target area or pest, regardless of application method. This requirement

can be satisfied by the use of invert emulsions, particulate sprays, or special drift control equipment such as the "Microfoil Boom" developed by Amchem Products, Inc. Ground spray equipment must be calibrated to emit a droplet size large enough to inhibit drift. Droplet size should exceed 200 microns to insure proper drift control. Fixed wing aircraft will not be used.

All applications must comply with USDA and E.P.A. restrictions. Unless specifically registered for aquatic weed control herbicides will not be applied within 50 feet of open water areas such as streams, ditches, lakes and ponds. Aerial and ground spray applications will leave a 100-foot untreated zone.

An unsprayed buffer zone of at least 100 feet will be left adjacent to all private property. Individual tree treatment methods can be used in this strip.

High volatile esters will not be used.

Advise concerned State and Federal Agencies of the herbicide projects and solicit their comments and advice.

All projects will be carefully monitored to assure that all necessary precautions are being observed.

Herbicides will be applied in such a manner that they will not contaminate food supplies, water systems, or municipal watersheds.

Water monitoring is now an established practice as a part of all aerial application of herbicides in the timber management program. Following

the Interim Guidelines, two Forests aerial sprayed with 2,4-D and 2,4,5-T in the summer of 1971. A one-hundred-foot set-back was maintained along stream courses and the microfoil boom was used to reduce drift (particle size approximately 800 microns w/boom). The highest concentrations found at the adjoining stream monitoring sites were 65 ppb (parts per billion) and 8.3 ppb on the two Forests. These concentrations were below levels known to affect aquatic organisms.

The Regional Chemical Use Committee has tentatively established 6 lbs. active ingredient per acre as the maximum for one application of herbicide unless a higher rate is recommended under the registration. The Committee also prescribes that retreatments, where needed, be no sooner than one year for 2,4,5-T and three years for picloram to prevent any accumulative effects of these herbicides in the soil or water.

Based on current label warnings the herbicide 2,4,5-T is not used in campground areas or around dwelling sites. It is registered for forest, pasture, and industrial site use. When used on pasture permit areas permittees are not to graze dairy animals for six-weeks after application or meat animals within two-weeks of slaughter.